BC Environment

A Review of the Ecology, Management and Conservation of the Northern Goshawk in British Columbia

by
J.M. Cooper
and
V. Stevens

Wildlife Bulletin No. B-101

March 2000

British Columbia, Canada's most westerly province, has a bounty of biological diversity. British Columbia's snowclad peaks, rain-drenched forests, arid grasslands, all sizes of rivers, lakes, and wetlands, and a long and rugged coast provide habitats for more species of living organisms than are found anywhere else in Canada. However, this very diversity means that there is much to be discovered about these organisms — their distribution, abundance, habitat requirements, and interrelationships with their environment. Increasing our knowledge of this biodiversity will help us with the complex task of sustainably managing our land and waters.

In 1992, the Provincial Government initiated a co-operative biodiversity research program with funding from the Corporate Resource Inventory Initiative, the British Columbia Ministries of Forests (Research Branch), Environment, Lands, and Parks (Wildlife and Habitat Protection Branches), and Tourism and Culture (Royal B.C. Museum), and the Forest Resource Development Agreement (FRDA II).

In 1995, the Ministry of Forests Research Branch and the Ministry of Environment, Lands and Parks developed a biodiversity research and extension strategy, with the assistance of the provincial research community. This strategy was presented to Forest Renewal BC (FRBC), who provided funding for a program beginning in 1995. The goal of the extension component of this program is to extend information to scientists, resource managers, and the public through biodiversity publications. These publications are intended to increase awareness and understanding of biodiversity, promote the concepts and importance of conserving biodiversity, and communicate provincial government initiatives related to biodiversity. We hope that they will be used as tools for the conservation of British Columbia's rich, living legacy.

For more information contact:

B.C. Ministry of Environment, Lands and Parks
Wildlife Branch
P.O. Box 9374 Stn. Prov. Govt.
Victoria BC V8W 9M4
or
B.C. Ministry of Forests Research Branch
P.O. Box 9519 Stn. Prov. Govt.
Victori, BC V8W 9C2
or
Royal B.C. Museum
P.O. Box 9815 Stn. Prov. Govt.
Victoria BC V8W 9W2

A REVIEW OF THE ECOLOGY, MANAGEMENT AND CONSERVATION OF THE NORTHERN GOSHAWK IN BRITISH COLUMBIA

by
John M. Cooper
and
Victoria Stevens

BRITISH COLUMBIA

Ministry of Environment, Lands and Parks
Wildlife Branch
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This report was commissioned by the Wildlife Branch and completed in 1999. The views expressed herein are those of the authors and do not necessarily represent those of the Ministry of Environment, Lands and Parks.

ABSTRACT

This document is both a thorough literature review of the distribution, taxonomy, status, biology and ecology of the Northern Goshawk, and an analysis of how the current conservation initiatives in British Columbia could serve the preservation of goshawks throughout the province. The information from the literature focuses on research in British Columbia, but puts it into both a global and North American context. This includes details on taxonomy, population biology, migration, habitat use and predator-prey relations.

Necessary background information for a discussion on habitat management is given in a section on potential threats to the species and the current status of efforts to address some of these threats. These efforts include research, protected areas, and the current legal framework for protecting both the birds and their habitat. More specifically, the portions of the Forest Practices Code that address habitat protection, especially for species at risk such as the Northern Goshawk, are outlined. These include landscape unit biodiversity, riparian management areas, old growth management areas, ungulate winter ranges, stand management provisions, wildlife tree patches and specific direction on identified wildlife. The differences between the identified wildlife provisions for the two subspecies recognized in British Columbia (*Accipiter gentilis atricapillus* and *A. g. laingi*) are described.

Regional planning tables and their Land and Resource Management Plans (LRMPs) provide another provincial initiative that affords the opportunity to include consideration of species of importance and their habitats. Special habitat protection for species in Higher Level Plans may be recommended by government if it is concluded that current measures are inadequate, or they can be brought forward independently by any non-government member of an LRMP table.

Conservation initiatives that focus on Northern Goshawks are outlined, including objectives, priorities, and all the currently applicable conservation mechanisms in British Columbia. Research needs are listed and those with the highest priority noted. It is recommended that the effectiveness of the current efforts to conserve goshawks be evaluated in the near future so that any necessary changes can be made.

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1 INTRODUCTION

A number of strategies for conservation of the Northern Goshawk (*Accipiter gentilis*) in North America are being developed and implemented (Crocker-Bedford 1990a, 1990b, 1994; Reynolds et al. 1992; Iverson et al. 1996; Bednarz 1999). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recently evaluated the status of the two subspecies of Northern Goshawks that occur in Canada, and reported *A. g. atricapillus* as "Not At Risk" and *A. g. laingi* as "Vulnerable" (Duncan and Kirk 1995). The addition of *A. g. laingi* to British Columbia's "Red List" as a candidate for designation as "Threatened" or "Endangered" (Ministry of Environment, Lands and Parks 1998), in combination with the species' use of older-aged forest habitat, has resulted in recognition among resource managers of the need for a comprehensive conservation plan in British Columbia. As a forest raptor, the long-term viability of Northern Goshawk populations in the province depends on our ability to manage for a balance between its habitat needs and the needs of the forest industry for timber.

This document provides a synopsis of Northern Goshawk ecology, habitat management options, conservation initiatives, research priorities and a method for evaluating the efficacy of conservation actions. The Review of Ecology and Conservation section provides the ecological background as a context for understanding how and why certain factors are considered threats to Northern Goshawk populations.

Following the assessment is a section on Habitat Management Options, which outlines the tools available for wildlife habitat conservation in British Columbia within the policy framework provided by the Forest Practices Code, the Protected Areas Strategy and the *Wildlife Act*. The Conservation Initiatives section discusses practical approaches to conserving habitat for Northern Goshawks. Then, the section on Research lists topics for which additional information is required to adequately manage for this species in British Columbia. A brief Evaluation section discusses ways to evaluate the success of the Conservation Initiatives.

This report was contracted by the Ministry of Environment, Lands and Parks, and was funded by Forest Renewal British Columbia. This document is intended for use by resource managers and wildlife biologists from government and industry, as well as by researchers, special interest groups and the general public.

2 A REVIEW OF ECOLOGY AND CONSERVATION

2.1 Distribution, Taxonomy and Status of the Northern Goshawk

2.1.1 Global

The Northern Goshawk (*Accipiter gentilis*) is widely distributed in boreal and temperate forests of the Holarctic. In North America, it ranges from near the tree line in Alaska and northern Canada south to Mexico in the west, and Pennsylvania in the east. In the Old World, it occurs from Great Britain, Scandinavia, northern Russia, and Siberia south to southern Europe, Iran, the Himalayan Mountains, eastern China, and Japan (American Ornithologists' Union 1983; Squires and Reynolds 1997).

There have been as many as nine (Brown and Amadon 1968), or 10 (Stresemann and Amadon 1979) recognised subspecies within the global range, with up to three subspecies recognised in North America (American Ornithologists' Union 1957; Squires and Reynolds 1997).

Over the past century, population declines of some subspecies have been reported, with habitat loss through logging identified as the primary cause. For example, Scandinavian populations are thought to have declined by 50-60% from the 1950s to the 1980s due to effects of logging (Widen 1997). Several other authors cited by Widen (1997) also contend that declines in Europe have been linked with deforestation. In Europe, direct persecution by humans, through shooting or trapping of birds to protect game bird populations, is also a likely major cause of decline (Squires and Reynolds 1997). Populations of *A. g. gentilis* were eliminated from Great Britain in the 1880s, largely through persecution (Newton 1986) and deforestation (Kenward et al. 1991), but were reintroduced in the 1960s, and were recently estimated to number about 200 individuals (Petty 1989). In Denmark, populations increased from the 1960s through the 1980s largely due to decreased persecution (Jorgenson 1989 cited in Widen 1997).

2.1.1 North America

The Northern Goshawk breeds from near tree line in west-central Alaska and across Canada, south along the Pacific coast through southeastern Alaska and coastal British Columbia to Washington. In the interior, it breeds south throughout British Columbia, forested parts

of the Prairie provinces, Ontario, Quebec, and Labrador to central California, Arizona, New Mexico, northern Minnesota, Wisconsin, and Michigan, and Pennsylvania; also in the Appalachian Mountains and Mexico (American Ornithologists' Union 1983; Johnsgard 1990; Marshall 1992; Duncan and Kirk 1995; Braun et al. 1996; Squires and Reynolds 1997).

Three subspecies have been recognised in North America: *A. g. atricapillus*, *A. g. apache* and *A. g. laingi*. *A. g. atricapillus* is found throughout forested areas of North America, except on the northwest coast, the extreme southwest USA, and Mexico (Squires and Reynolds 1997). *A. g. apache* occurs in southern Arizona, New Mexico and Mexico (Whaley and White 1994). *A. g. laingi* (Queen Charlotte Goshawk) occurs in southeast Alaska (Titus et al. 1994), on the coastal islands of British Columbia (American Ornithologists' Union 1957), and, perhaps, the Olympic Peninsula (Beebe 1974) and even coastal Washington and Oregon (Jewett et al. 1953). These subspecies are defined on the basis of colour and morphological differences (Taverner 1940), but the genetic validity of the *apache* and *laingi* subspecies is under debate. The U.S. Fish and Wildlife Service now considers the issue of recognition of *apache* as a subspecies to be unresolved (U.S. Fish and Wildlife Service 1998). No significant genetic differences were found in blood samples of the three subspecies (Gavin and May 1995), but samples from Vancouver Island or the Queen Charlotte Islands, which are the core range for *A. g. laingi* (Iverson et al. 1996) were not used. Flatten et al. (1998) compared morphometric data from captured birds in southeast Alaska and Vancouver Island, and from museum specimens from the Queen Charlotte Islands, and confirmed that *A. g. laingi* is smaller and darker than *A. g. atricapillus*.

The United States Department of Interior (USDI) Fish and Wildlife Service (1992 in Crocker-Bedford 1994) designated the Northern Goshawk (including all three subspecies occurring in the USA) as a Category 2 candidate species for Threatened or Endangered status in 1991; however, the Fish and Wildlife Service no longer maintains a list of Category 2 candidate species (USDI Fish and Wildlife Service 1996 in Iverson et al. 1996). The Northern Goshawk is on the Sensitive Species lists of the Pacific Southwest (1981), Southwest (1982), Intermountain (1992), Rocky Mountains (1993) and Alaska (1994) Forest Service Regions. At the state level, the Northern Goshawk is listed as a high priority species by state working groups of Partners in Flight in Alaska, Arizona, California, Montana, Nevada and New Mexico. In June 1998, the U.S. Fish and Wildlife Service denied a listing of the Northern Goshawk as an Endangered species in the contiguous United States west of the 100° meridian (U.S. Fish and Wildlife Service 1998).

Concerns over possible population declines of goshawks in the southwest USA (Crocker-Bedford 1990a) have sparked intense conservation efforts in that region (Reynolds et al. 1992), and fuelled the demand for research on effects of logging on populations throughout North America (DeStefano 1998). In Mexico, *A. g. apache* is considered Threatened (Estados Unidos Mexicanos 1994).

On the Pacific coast, *A. g. laingi* is ranked as "Critically imperilled globally" or "Imperilled globally" (T1/T2), by the Alaska Natural Heritage Program (West 1993 in Duncan and Kirk 1995; West 1994). In 1994, *A. g. laingi* was formally designated as a "species of special concern" by the Alaska Department of Fish and Game (Iverson et al. 1996). A petition to declare *A. g. laingi* an Endangered species in the USA was denied in September 1997 (Federal Register 1997).

Although some populations/subspecies of goshawks are widely suspected of declining in North America, a recent review of published literature has found no definitive evidence to support the contention that declines are occurring (Kennedy 1997). This may be due in part because baseline data, which are needed to track population trends, are lacking. For example, in Oregon, goshawks do not occur in large parts of the coast and northwest, areas with high rates of logging of mature timber (Reynolds and Meslow 1984;, DeStefano and McCloskey 1997), but due to the lack of baseline data, it is unknown if goshawks occurred there prior to logging. In the northeastern USA, populations of *A. g. atricapillus* are thought to be recovering from lows earlier in the century. These increases are widely purported to be responses to reforestation of agricultural lands (Kennedy 1997). The obvious conclusion here is that, in order for such a recovery to occur, populations must have declined earlier when forests were converted to farmland. In Wisconsin, goshawks were not thought to be declining as they were found to nest widely in northern parts of the state with no evidence of range contraction (Rosenfield et al. 1998).

2.1.3 Canada

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) evaluated both subspecies that occur in Canada: *A. g. laingi* (which occurs only in British Columbia) was designated Vulnerable, whereas *A. g. atricapillus* was designated Not at Risk (Duncan and

Kirk 1995). Recent surveys (1995-1998) on Vancouver Island and the Queen Charlotte Islands of British Columbia suggest there may be less than 200 pairs of *A. g. laingi* in Canada, which would likely warrant a Threatened COSEWIC status.

2.1.4 British Columbia

Two subspecies of Northern Goshawk are recognised in British Columbia (Campbell et al. 1990). *A. g. laingi* occurs on the Queen Charlotte Islands and Vancouver Island (American Ornithologists' Union 1957), probably on other large coastal islands, and possibly on the coastal mainland. This subspecies was first proposed on the basis of darker plumage and smaller size by Taverner (1940), who considered its range to be restricted to the coastal islands; primarily the Queen Charlotte Islands. Beebe (1974) suggested a third subspecies in British Columbia, endemic to Vancouver Island, but Johnson (1989) used morphometric measurements to demonstrate that individuals from Vancouver Island and the Queen Charlotte Islands were similar in size and were the same subspecies, but were significantly smaller than those from mainland British Columbia. A more detailed analysis supporting *A. g. laingi* subspecies delineation on the basis of body size is provided by Whaley (1988) and Whaley and White (1994).

Crocker-Bedford (1994) identified five populations of *A. g. laingi*, based on slight differences in morphology (size and plumage) and geographic separation: northern southeast Alaska, southern southeast Alaska, Queen Charlotte Islands, Vancouver Island and the Olympic Peninsula.

A. g. atricapillus occurs throughout interior British Columbia (Campbell et al. 1990). The taxonomy of coastal mainland goshawks is uncertain. Either or both subspecies may occur, but *A. g. atricapillus* is widely assumed to occur on the coastal mainland. However, it seems reasonable to expect that *A. g. laingi* could occur on the coastal mainland as well (F. L. Beebe, pers. comm.).

The British Columbia Conservation Data Centre (CDC) ranks *A. g. laingi* as S2B, SZN (imperilled in British Columbia due to rarity and perceived threats to habitat). *A. g. laingi* is currently on the provincial "Red List" as a candidate species for Endangered or Threatened status (Ministry of the Environment, Lands and Parks 1998). *A. g. atricapillus* is ranked as S4 (demonstrably secure in British Columbia), and as such is not considered at risk and is no longer tracked by the CDC.

2.1.5 Populations in British Columbia

The Northern Goshawk is a rare to uncommon forest raptor, but it is widely distributed and breeds throughout the province (Campbell et al. 1990). Records of breeding are relatively few, however. Campbell et al. (1990) compiled 33 breeding records, including 21 records of nests, compared to, for example, 352 breeding records and 212 records of nests for the fairly common, highly conspicuous, and very widespread Red-tailed Hawk (*Buteo jamaicensis*). Northern interior populations are thought to be more abundant than coastal or southern interior populations (Campbell et al. 1990), but data on densities are generally lacking so comparisons between regions are equivocal.

During the last few years, inventory of nesting Northern Goshawks has occurred in several regions of British Columbia in response to the high conservation priority placed on this species in neighbouring regions of the United States, and subsequently in British Columbia by the Ministry of Environment, Lands and Parks and the Ministry of Forests through the Forest Practices Code. These inventories have experienced various levels of success. On Vancouver Island, 28 new active territories with nests were found during 1991–1997: 1 nest–1991, 4 nests–1994, 6 nests-1995, 8 nests–1996, 9 nests–1997 (McClaren 1997). On the Queen Charlotte Islands, 3 active nests have been reported during the last three years: 1 nest–1995 (Bonnell and Chytyk 1995), 2 nests–1996 (Chytyk and Dhanwant 1997), 0 nests–1997 (Chytyk et al. 1997). In the Kootenay Wildlife Region, nesting at 8 sites in the last 5 years with 3 active nests in 1997 has been confirmed (T. Antifeau, pers. comm.). In 1996, inventory in the Cariboo Wildlife Region produced 2 active nests (Bosakowski and Rithaler 1997). In the Kispiox Forest District, 3 new nests were found in 1995, none in 1996, and 9 new nests in 1997 (Mahon and Franklin 1997). In the Fort Nelson Forest District, no active nests were found during a few weeks of surveys in 1997, but 83 large stick nests – potential Northern Goshawk nests – were found during winter aerial surveys in 1997 and 1998 (Bennett 1998).

The above-mentioned surveys have produced 44 active territories, more than double the number reported by Campbell et al. (1990). Population estimates, based on detections of birds or nests, however, have yet to be attempted in British Columbia. A habitat capability model developed for *A. g. laingi*, estimated 1700 pairs in coastal British Columbia and 800 pairs in southeast Alaska (Crocker-Bedford 1990b). Refinements to the

model reduced the estimate for southeast Alaska to 100-200 pairs (Crocker-Bedford 1994). Although a new estimate for British Columbia was not made, Crocker-Bedford (1994) suggested the British Columbia population was substantially less than 1700 pairs; a conclusion that seems reasonable given the results of recent surveys on Vancouver Island (McClaren 1997, 1998) and the Queen Charlotte Islands (Chytyk and Dhanwant 1997; Chytyk et al. 1997). Those same surveys suggest that, although uncalculated as yet, densities on Vancouver Island are higher, possibly much higher, than on the Queen Charlotte Islands. Densities in other parts of western North America generally range from 2.4 to 10.7 pairs/100 km^2 (Squires and Reynolds 1997).

Population trends are unknown in British Columbia and, apparently, anywhere else in western North America. Some studies which purport declines for *A. g. atricapillus*, have not applied sufficiently rigorous statistical methods to determine trends (Kennedy 1997). However, Crocker-Bedford (1998) and Smallwood (1998) point out that it may be nearly impossible (due to practical factors such as costs) to obtain a data set for this raptor with sufficient rigour to prove any trend statistically. For *A. g. laingi*, Crocker-Bedford (1990b) estimates with his habitat capability model that habitat for 1150 pairs has been converted to early seral forest in southeast Alaska and coastal British Columbia due to logging of old-growth forests. Even if Crocker-Bedford's predictions are inaccurate (Kennedy 1997, 1998), if we use deductive reasoning as he suggests (Crocker-Bedford 1998), the trend seems to be inevitably downward for *A. g. laingi* in British Columbia. Furthermore, because all goshawks avoid early successional stages and immature forests for nesting and foraging (Widen 1989; Austin 1993; Bright-Smith and Mannan 1994; Hargis et al. 1994; Iverson et al. 1996), and because of the extent of conversion of old-growth and suitable second-growth forest to early seral stages in British Columbia, it seems reasonable to predict that populations of both subspecies occurring in the province might be declining.

2.2 Northern Goshawk Biology and Ecology

2.2.1 Reproduction, productivity and mortality

The Northern Goshawk forms a monogamous pair bond and shows strong mate (Detrich and Woodbridge 1994) and nesting area fidelity between years (Crocker-Bedford 1990a; Reynolds and Joy 1998). However, about 25% of breeding females breed in different areas one year to the next (P. Kennedy, pers. comm.). Although individual females can breed as yearlings, most breeders in a given population are $\geq$ 2 years old.

Territorial behaviour has been observed as early as February in the mid-Atlantic states (Speiser and Bosakowski 1991); and mid-March in British Columbia (Beebe 1974). Some pairs may remain near the nest year-round (Doyle and Smith 1994). Eggs are generally laid between mid-April and late May (McGowan 1975; Reynolds and Wight 1978; Bull and Hohmann 1994; Iverson et al. 1996); but as early as 7 April has been reported in British Columbia (Campbell et al. 1990). Egg-laying may be delayed during cold, wet springs and at higher elevations (Squires and Reynolds 1997).

The incubation period ranges from 28 to 32 days per egg (Beebe 1974; McGowan 1975; Reynolds and Wight 1978), beginning with the first or second egg (Beebe 1974; Squires and Reynolds 1997). Incubation is primarily done by the female. During this period, males hunt and deliver food to the female (Brown and Amadon 1968), but occasionally incubate (Lee 1981;, E. McClaren, pers. comm.). Hatching and fledging dates are variable, ranging from 13 May to 25 June, and 25 June to 28 July, respectively (McGowan 1975; Reynolds and Wight 1978; Bull and Hohmann 1994). In British Columbia, the earliest recorded fledging date is 25 June (Dease Lake), and the latest was calculated to be in the last week of August (Campbell et al. 1990). On Vancouver Island, seven broods fledged from early to mid-July 1997 (McClaren 1997). The Northern Goshawk has a relatively long post-fledging dependency period that can be several weeks in duration (Ward and Kennedy, unpubl. data). In southeast Alaska, all juveniles appear to disperse from natal areas before 5 September (Titus et al. 1995).

Clutch sizes usually range between two and four eggs (Squires and Reynolds 1997). In British Columbia, clutch sizes also range from two to four eggs (Campbell et al.1990), but three eggs is the norm (Beebe 1974). Mean clutch size for North America is 2.7 eggs (Squires and Reynolds 1997). Nesting success is highly variable but, in most studies, 80-94% of nest attempts produced at least one fledgling (Reynolds and Wight 1978; Bull and Hohmann 1994; Squires and Reynolds 1997). In the Yukon, the average number of fledglings varied from 0/nest to 3.9/ nest (Doyle and Smith 1994). On the Olympic Peninsula of Washington, 2.3 young fledged/ breeding attempt in 1996, and 2.0 in 1997 (Finn et al. 1998). In Oregon, an average of 1.2 young fledged per nest attempt (Bull and Hohmann 1994). In Alaska, an average 2.0 young fledged per nest attempt (McGowan 1975). In 1996, 14 successful nests produced 2.1 fledglings/nest on Vancouver Island. In 1997, 15 successful nests on Vancouver Island produced an average

1.7 fledglings (E. McClaren, pers. comm.). Nest failure followed by a replacement clutch, has been observed (Johnsgard 1990), but is likely rare as goshawks require the full spring and summer season to nest successfully.

Variation in goshawk productivity is associated mainly with prey abundance (McGowan 1975; Crocker-Bedford 1990a; Doyle and Smith 1994) and habitat structure for accessibility to prey (Widen 1989; Crocker-Bedford 1990a; Beier and Drennan 1997); but also with weather (Penteriani 1997), age of breeders, nestling predation, adult mortality, disease and human disturbance. On Vancouver Island, low productivity in 1995 was thought to be related to low abundance of Red Squirrel (*Tamias hudsonicus*), a primary prey species (T. Ethier, pers. comm.). There is evidence that nestling survival is directly dependent on food supply, but an alternative explanation is that higher food abundance allows adults to remain longer within the nest area, thus decreasing predation of nestlings (Ward and Kennedy 1996). Initiation of breeding is generally dependent on prey availability, the presence of a suitable mate, and the availability of unoccupied suitable nesting habitat (McGowan 1975; Hennessy 1978; Reynolds and Wight 1978; Doyle and Smith 1994; Iverson et al. 1996; Finn 1997).

Predation of eggs and nestlings can affect productivity of individual pairs; for example Fishers (*Martes pennanti*) were taking eggs, nestlings, and adult females in a Wisconsin population (Erdman et al. 1998). Although Erdman et al. (1998) speculated that an increasing Fisher population reduced productivity in that population, other factors may be involved (R. Rosenfield, pers. comm.). Other predators of nestlings include the Great Horned Owl (*Bubo virginianus*), and mammals such as the Wolverine (*Gulo gulo*) (Doyle 1995). On the Queen Charlotte Islands, Raccoons (*Procyon lotor*) were recently suspected of predating a nest (K. Dhanwant, pers. comm.). Siblicide occurs during food shortages (Squires and Reynolds 1997).

Estimates of mortality rates of adults and juveniles following the breeding season are difficult to make and little data exists for North American populations. In Arizona, estimated annual survival was 87% for females >1 year old and 69% for males >1 year old (Kennedy 1997; Squires and Reynolds 1997). In Alaska, annual survival of *A. g. laingi* adults was 76% for males and females; late winter and early spring was the period of highest mortality (Titus et al. 1995). On Vancouver Island, 3 adult females and 1 immature female of 12 adult female and 1 immature female tagged with transmitters in 1996 and 1997 were known to be dead by March 1998 (McClaren 1998). Long-term survival rates of juveniles and recruitment rates into the breeding population are unknown. European research indicates that mortality is highest in the first year (58-64%) and decreases with age (Newton 1979).

Palmer (1988) suggests a maximum life span of 20 years in North America, but provides no supporting evidence. The Northern Goshawk in Europe has been known to live up to 19 years, both in the wild and in captivity (Newton 1979). Some direct causes of adult mortality are starvation, predation, disease, and direct and indirect killing by humans (Beebe 1974; Snyder and Wiley 19 /6 in Palmer 1988; Newton 1979; Duncan and Kirk 1995; Squires a Reynolds 1997).

2.2.2 Migration, seasonal movement, and juvenile dispersal

The Northern Goshawk is a nomadic species but is probably resident year-round in most years throughout most of its range (Squires and Reynolds 1997). Residency appears typical for both *A. g. laingi* and *A. g. atricapillus* in southeast and central Alaska (McGowan 1975; Crocker-Bedford 1994; Titus et al. 1994; ADF&G 1996). Home ranges tend to increase with latitude, from south to north: 1 pair/910 ha in Arizona (Crocker-Bedford and Chaney 1988), 1 pair/1430 ha and 1 pair/2750 ha in Oregon (Reynolds and Wight 1978; DeStefano et al. 1994a), and 1 pair/1500 ha, 1100 ha, 1600 ha and 37,200 ha over four consecutive years in Alaska (McGowan 1975).

In southeast Alaska, adult breeders dispersed rather than migrated; some used overlapping summer and winter ranges whereas others dispersed as far as 90 km from their nest area for the winter (ADFG 1996). On Vancouver Island and Queen Charlotte Islands, *A. g. laingi* is almost certainly resident (Taverner 1940; Beebe 1974; Campbell et al. 1990). On Vancouver Island, recent data from 17 radio-tagged birds showed a maximum movement from nest sites of 68 km from July through March, which suggests residency. (E. McClaren, unpubl. data).

When it occurs, migration or nomadic behaviour is usually associated with food shortages (Squires and Reynolds 1997). Migration may range from simple seasonal altitudinal movements to large-scale irruptions into southern latitudes. For example, in the Yukon, *A. g. atricapillus* densities in winter remain similar to summer densities during winters with high abundance of Snowshoe Hare (*Lepus americanus*), but densities can be very low during winters with low hare abundance (Doyle and Smith 1994). Four goshawks banded in Minnesota in winter were subsequently found in north-

eastern British Columbia, 1250 to 1400 km from their banding location (Campbell et al. 1990), suggesting migration over long distances can occur in some years. In British Columbia, a significant irruption into southern areas occurred in the winter of 1954-55 (Keith 1983); minor irruptions occurred in the winters of 1975, 1978, 1980, and 1983 (Campbell et al. 1990).

In British Columbia, spring migration occurs from late February through April, and fall migration occurs from September through November (Campbell et al. 1990). Beebe (1974) suspected that a major migratory corridor existed along the east slope of the Rocky Mountains. This suspicion has been supported in recent years by hawk migration counts (P. Sherrington, pers. comm.). During these counts, noticeable southward movements of Northern Goshawks have occurred in fall along the east slope (Andy Stewart, pers. comm.). Incidental observations in British Columbia suggest that migrants move along mountain ridges (Campbell et al. 1990). On Vancouver Island, telemetry is providing some preliminary indications of winter movements to large contiguous stands of old-growth or >60 year old second-growth (D. Doyle, pers. comm.).

When migration occurs, juvenile goshawks are known to migrate earlier and more frequently than adults (Kenward et al. 1993), a reasonable expectation given that juveniles usually must disperse from their natal areas to find unoccupied habitat. In southeast Alaska, 14 radio-tagged juvenile goshawks dispersed from nest areas 5 to 7 weeks (August 5 to September 5) after fledging, and were tracked to distances ranging from 16 to 151 km from their natal sites (Titus et al. 1994). Juvenile residency was well-documented in southeast Alaska when 23 of 27 independent juveniles dispersed an average of 60 km from their natal site; then remained fairly consistently in winter-use areas; the other four were not found and may have left the region or died (ADFG 1996).

2.2.3 Habitat

Across North America, the Northern Goshawk uses a variety of forest types and successional stages for year-round habitat. Nesting habitat can occur from near sea level up to near the tree line (McGowan 1975; Hennessy 1978; Moore and Henry 1983; Hall 1984; Speiser and Bosakowski 1987; Crocker-Bedford and Chaney 1988; Hayward and Escano 1989; Austin 1993; Harris et al. 1994; Titus et al. 1994, 1995; Braun et al. 1996; Squires and Rigger 1996). In western and central North America, goshawk breeding habitat use is concentrated in areas with significant mature to old-growth forests (Hennessy 1978; Reynolds et al. 1982; Moore and Henry 1983; Hall 1984; Speiser and Bosakowski 1987; Crocker-Bedford and Chaney 1988; Bosakowski and Speiser 1994; Harris et al. 1994; Squires and Rigger 1996; Chytyk and Dhanwant 1997; McClaren 1997); although younger seral stages and pine plantations have been used in Wisconsin and Michigan (Rosenfield et al. 1998). In general, in western North America, breeding habitat is mainly coniferous forests including ponderosa pine, Douglas-fir, lodgepole pine, western hemlock, and various spruce spp., but also deciduous or mixed forests dominated by trembling aspen and paper birch (Squires and Reynolds 1997).

2.2.4 Breeding habitat

The Northern Goshawk is considered a habitat generalist at large spatial scales and at the species level (Federal Register 1998 [U.S.]; R. Rosenfield, pers. comm.), as it is known to breed in a wide range of forest types. But at a local or individual scale, it has a complexity of habitat needs that are more specialised. Although some pairs may nest in intermediate, even-aged stands, most nests are found in stands with mature or old-growth characteristics. These stands do not necessarily need to be continuous, but significant amounts seem to be needed. For example, in southeast Alaska, minimum amounts of old-growth forests in goshawk use areas (areas in which radio locations were made of radio-tagged nesting birds) were 23% and 28% for males and females respectively. In areas with less than those amounts of old-growth forest there was no goshawk use (Iverson et al. 1996). It should be noted that this study area contained virtually no mature forest (K. Titus, pers. comm.). Therein lies the dilemma (conservation versus economics) facing resource managers in regions, such as British Columbia, where logging is an economically essential industry. A second dilemma is that differences in habitat needs between *A. g. laingi* and *A. g. atricapillus* are poorly known, but must be seriously considered given the management implications in British Columbia. We draw attention to Beebe's (1974) observation that "Only on Vancouver Island have I found goshawks nesting deep in continuous forest far from any clearing or lake."; it remains to be seen if there are such fundamental differences between the subspecies.

High canopy closure is the single most consistent nesting habitat feature. High canopy closure may provide protection from predators, and promote more open spaces under the canopy and in the undergrowth that allows clear flight paths. Streams, wetlands, or lakes are often associated with nesting areas but are not a habitat requirement (e.g., Reynolds et al. 1982; Bull and

Hohmann 1994). Small forest openings, such as where one or two trees have fallen creating more open air space at the nest tree, are often associated with nest sites (Chytyk and Dhanwant 1997; Squires and Reynolds 1997).

Most recent studies of breeding habitat have focused on four distinctive spatial habitat components: **1) nest site, 2) nesting area, 3) post-fledging area, and 4) foraging area** (Kennedy et al. 1994).

1) The **nest site** is defined as a known nest tree, and a 1 ha area surrounding it (Titus et al. 1994; Province of British Columbia 1999a). A variety of coniferous and deciduous tree species are used by goshawks as nest trees. In Oregon, ponderosa pine, lodgepole pine, Douglas-fir and western larch were commonly chosen for nest trees (Reynolds et al. 1982; DeStefano and Meslow 1992; Reynolds et al. 1982; Bull and Hohmann 1994). In southeast Alaska, Sitka spruce and western hemlock were mainly used (Titus et al. 1994). In interior Alaska, paper birch was used mainly (McGowan 1975). In the Yukon, nests were found in spruce or trembling aspen (Doyle and Smith 1994).

In British Columbia, incidental records of nest trees included mainly trembling aspen and Douglas-fir, but black cottonwood, larch, ponderosa pine, lodgepole pine, birch and spruce were also used (Campbell et al. 1990; T. Antifeau, pers. comm.). On Vancouver Island, recent surveys found most nests in old-growth trees, mainly in live Douglas-fir and western hemlock, but a few were in dead coniferous trees (Douglas-fir and western hemlock), live red alder, (McClaren 1997) or in mature second-growth coniferous stands (D. Doyle, pers. comm.). On the Queen Charlotte Islands, all three nests were in dead mature or old-growth western hemlocks adjacent to small windthrow openings (Chytyk and Dhanwant 1997). In the Cariboo Region, nest trees included Douglas-fir, lodgepole pine, and trembling aspen. In the Kispiox Forest District, nests were in mature or old-growth western hemlock or amabilis fir (Mahon and Franklin 1997).

Although nest tree species and absolute tree size may vary widely between regions, the important points are that the nest tree, on average, is relatively larger than the trees in the surrounding stand, and that Northern Goshawks appear to nest in stands with trees consistently larger than in surrounding forests (Reynolds et al. 1982; Moore and Henny 1983; Speiser and Bosakowski 1987; Crocker-Bedford and Chaney 1988; Squires and Rigger 1996; Rosenfield et al. 1998; *in British Columbia* – Bosakowski and Rithaler 1997; Chytyk and Dhanwant 1997; McClaren 1997; Rosenfield et al. 1998; T. Ethier pers. comm.). In most of British Columbia this is also the most valuable merchantable timber.

2) The second habitat category, the **nesting area**, is generally considered to be an 8 – 20 ha area (Kennedy 1988;, Reynolds et al. 1992) including several nest trees, and is the centre for breeding behaviours and activities from courtship to fledging of young (Reynolds et al. 1992; Woodbridge and Detrich 1994). The size and shape of a nest area depends on topography and the availability of stands of relatively large, densely distributed trees (Moore and Henny 1983; Reynolds 1983; Crocker-Bedford and Chaney 1988). Eight characteristics common to most (there are regional variations) nesting areas in western North America (Marshall 1992; Duncan and Kirk 1995) include:

1. mature to old-growth forests, nests located in stands with high tree basal area;
2. canopy closure >60%;
3. open understory;
4. gentle to moderate incline (<40 %), nests generally on benches, slope toes or level ground;
5. lower 1/3 or bottom of slope;
6. northerly exposure, northeast to northwest;
7. often close to perennial water source;
8. proximity to abundant prey base.

Of these eight features, seven seem to be associated with nesting habitat in British Columbia; the exception is aspect. On the Queen Charlotte Islands, nests were on southwest-facing slopes (Chytyk and Dhanwant 1997); compared to northeast slopes in the Kispiox (Mahon and Franklin 1997), southeast to west facing slopes in the Kootenays (T. Antifeau, pers. comm.) and all aspects on Vancouver Island (McClaren 1997)

On Vancouver Island, nesting areas were found in contiguous old-growth forest (14 of 28 territories), second-growth (9 nests), and fragmented old-growth (5 nests); (E. McClaren, unpubl. data). On the Queen Charlotte Islands, 3 nests were found in contiguous western hemlock old-growth, in the bottom third of gentle, southwest facing slopes averaging 34°. In the Cariboo, nest areas were in mature or old-growth stands, but in localities fragmented by logging (Bosakowski and Rithaler 1997).

In southeast Alaska, where nesting habitat was limited to old-growth stands because of the disturbance history of the study area, goshawks selected closed, multi-layered canopies, in more homogenous stands with less edge. These stands were generally the more productive old-growth ones (Iverson et al. 1996). In Oregon, 86% of active nests (n=38) were in mid-to-late structural stage stands with >50% canopy closure (Desimone 1997). This study also showed a strong tendency for

nest sites to remain active over a number of years if a high percentage (>50%) of mature structural stages were retained within a 52 ha circular plot around the nest.

3) The third habitat category, the **post-fledging area (PFA)**, is a variable environment which generally resembles the structural and vegetative conditions of the nest area. The PFA is an area of intensive activity, used by both adults and fledglings during the fledgling dependency period (Marshall 1992; Reynolds et al. 1992; Kennedy et al. 1994). Key features include canopy closure >50%, well- developed understories, and structural attributes such as snags, coarse woody debris and forest openings. These qualities provide fledglings with cover from predators, and ample prey to develop hunting skills prior to dispersal (Kennedy 1988; Reynolds et al. 1992; Kenward et al. 1993; Kennedy et al. 1994). Size estimates of the PFA range from 120 to 240 ha (mean = 170 ha) and may correspond to the defended area of a breeding pair (Reynolds et al. 1992; Kennedy et al. 1994). In British Columbia, the PFA is defined as a 240 ha zone including the active and alternate nest trees, nest sites and nest areas (Province of British Columbia 1999a). This number is an estimate based on data from other North American jurisdictions as no research on PFAs has been conducted in British Columbia.

In southeast Alaska, the PFA appeared to be much smaller than reported in other studies, averaging only 26 ha (Iverson et al. 1996). This result may have significant and obvious implications for managing habitat needs of *A. g. laingi* in British Columbia. However, in some cases fledglings may remain dependent on adults after dispersing as far as 1.5 km or more from the nest site (Kenward et al. 1993).

4) The fourth habitat category, the **foraging area**, comprises the entire breeding home range that is used for hunting. The Northern Goshawk forages in a wide range of habitats over its range, but regional preferences have been documented. The foraging area typically contains more diverse habitats than the nest area or PFA, and is often described as a structural and seral mosaic (Reynolds et al. 1992).

Prey abundance and prey availability drive the use of foraging habitat, and prey availability is usually affected by vegetation structural attributes. Consequently, goshawks forage in areas that have the following attributes: 1) adequate prey; 2) sufficient cover to conceal the goshawk's approach to prey; 3) not too much cover so that prey can escape or flight paths are obstructed; and 4) suitable perches available for the goshawk's spot and attack hunting method (Beebe 1974; Kenward 1982; Reynolds and Meslow 1984; Widen 1989; Johnsgard 1990; Beier and Drennan 1997; Squires and Reynolds 1997). When prey are particularly abundant, natural openings, forest edges, clearcuts and even agricultural lands may be used for foraging, but goshawks may be excluded from these niches by other raptor species, such as Red-tailed Hawk, which are better adapted to treeless environments (Kenward and Widen 1989; Widen 1989; Crocker-Bedford 1990a; Marshall 1992). This is not such a problem in much of interior British Columbia during winter when Red-tailed Hawks have largely migrated south (A. Stewart, pers. comm.), but there may be some pressure exerted on goshawks on eastern Vancouver Island by migrating and wintering populations of Red-tailed Hawks.

Goshawks forage in all layers of a forest, from the ground up to the aerial zones above the canopy, but tend to concentrate efforts in the ground-shrub layer (Reynolds and Meslow 1984). Although edges and open areas can be used for foraging, and seem to be regularly used in interior British Columbia by *A. g. atricapillus* (Beebe 1974; J. Cooper, pers. obs.), *A. g. laingi* seems to use unbroken forests for foraging, and have no association with edges (Iverson et al. 1996).

The large body size and hunting strategies of this species preclude the use of young, densely stocked stands for foraging (Reynolds et al. 1982; Moore and Henry 1983; Hayward and Escano 1989; Duncan and Kirk 1995; Squires and Rigger 1996). Therefore, regenerating early seral stages are less suitable as foraging habitat. In southeast Alaska, goshawks show a strong preference for old-growth and mature forests, and tend to avoid early successional stands and clearcuts (Titus et al. 1994, 1995). On Vancouver Island, three territorial male *A. g. laingi* showed variable use of old-growth and second-growth habitat in 1997. One male consistently used only old-growth, while two other males used second-growth more than old-growth (E. McClaren, unpubl. data). The second-growth stands were mostly between 60 and 100 years old, but stands as young as 40 years old were used occasionally. Note that, in coastal British Columbia on good growing sites, 40-year-old second growth trees can be as large or larger than old-growth trees in the interior.

Breeding season home ranges can vary widely across regions and between individuals in a population. Mean home ranges in North America range from 570-1500 ha (Squires and Reynolds 1997). In southeast Alaska, home ranges varied from 270 ha to 111,400 ha (Titus et al. 1994). Elsewhere, home ranges in Oregon were from 1083 to 6908 ha (Austin 1993), in Arizona from 860 to 2530 ha (Bright-Smith and Mannan 1994) or 2025 to 2430 ha (Reynolds et al. 1992), and in

California were an average of 1550 (890 ha (Harris et al. 1994). On Vancouver Island, one nesting male was located by telemetry an average of 3.2 km from his nest, but one nesting female, when away from the nest, was found an average of 21.6 km from her nest (McClaren 1997). The latter result suggests that home ranges for nesting birds can be quite large. Nest spacing tends to be regular. Mean distances between nests thought to be in neighbouring territories, range from 3.0 km in Arizona (Reynolds et al. 1992), 3.3 km in California (Woodbridge and Detrich 1994), and 5.6 km in Oregon (Reynolds and Wight 1978). On Vancouver Island, one cluster of 12 nests had a mean inter-nest distance of 8.7 ± 4.5 km and minimum distance of 3.2 km (McClaren 1998).

2.2.5 Nonbreeding habitat

Nonbreeding habitat use is poorly understood (Squires and Reynolds 1997), but when studied, has been found similar to breeding habitat (Widen 1989; Iverson et al. 1996). It is likely that individuals shift to areas of highest prey availability which may mean lower elevations and narrower habitat use than during the summer. Prey abundance and availability may be the primary influence on nonbreeding habitat use (Squires and Reynolds 1997). Although goshawks may frequent edge habitats more commonly in winter (agricultural landscapes for example), mature or old-growth forests are still used more often than younger forests and clearcuts. The most extensive analysis of nonbreeding habitat use comes from southeast Alaska where goshawks strongly selected productive (relatively high commercial timber yields) old-growth forest. Mature second-growth, scrub forest, and poor quality old-growth were selected significantly less than the higher quality old-growth, and early seral stands, clearcuts, and alpine areas were avoided (Iverson et al. 1996).

In Sweden, winter home ranges were estimated to be 5100 ha (male) and 6200 ha (female) (range 1800 to 9200 ha, sexes combined; Widen 1985). In California, home ranges for nonbreeding males ranged from 1300 to 15,400 ha, and for females ranged from 1200 to 4000 ha (Keane and Morrison 1994). In southeast Alaska, nonbreeding home ranges were estimated to exceed 8200 ha for both sexes (Iverson et al. 1996).

2.2.6 Northern Goshawk predator-prey ecology

The Northern Goshawk preys on a wide range of small to medium-sized mammals and birds depending on season and region. Geography and variation in prey fauna available in different forest types explain much of the variation in local goshawk diets (R. Reynolds, pers. comm.). During the nesting season, mammals were taken more often in interior Alaska, Arizona, Nevada, Utah, and Yukon; birds were taken more often in southeast Alaska, California, New Mexico, and Oregon (Titus et al. 1994; Squires and Reynolds 1997). In Washington, coastal goshawks took more birds (53%) than mammals, compared to interior goshawks (47%), with squirrels, grouse, and Snowshoe Hares being the main prey (Watson et al. 1998). Common prey species include tree squirrels, ground squirrels, rabbits, Snowshoe Hare, woodpeckers, grouse, corvids, and various large songbirds (Squires and Reynolds 1997). In southeast Alaska, the most common prey were Steller's Jay (*Cyanocitta stelleri*), Blue and Spruce grouse (*Dendragapus obscurus* and *D. canadensis*), Varied Thrush (*Ixoreus naevius*), Red Squirrels, and woodpeckers; the next most common prey were Sharp-shinned Hawk (*Accipiter striatus*), alcids, yellowlegs, ptarmigan, and Northwestern Crow (*Corvus caurinus*) (Titus et al. 1994). Northern Goshawks occasionally use carrion (Squires 1995).

Most studies speculate that nesting areas must be in proximity to areas with high prey availability (P. Kennedy, pers. comm.). One study in Arizona showed that nesting areas were not centred in areas with high prey availability, with the implication that considerable movement to foraging areas occurred (Beier and Drennan 1997).

In northern British Columbia, and some other parts of the interior, Beebe (1974) infers that the goshawk's main prey includes grouse, Snowshoe Hare, and Red Squirrel, especially in winter; in summer, ground squirrels become very important. In the Kispiox Forest District, an analysis of 6 pellets collected near nests in 1996 showed that mammals (64%), mainly Red Squirrel (55% of all prey items) were taken more frequently than birds (36%) (Roberts 1997). The remains of Steller's Jay and Three-toed Woodpecker (*Picoides tridactylus*) were found at one nest (Mahon and Franklin 1997).

On the coast, Beebe (1974) states that *A. g. laingi* on Vancouver Island take mainly Steller's Jays and Varied Thrushes; whereas, on the Queen Charlotte Islands, they take mainly Northwestern Crows. Beebe's assertion that the Northwestern Crow is a primary prey species on the Queen Charlotte Islands may be true for goshawks that nest along the coastline. However, Chytyk and Dhanwant (1997) found Red Squirrel, Red-breasted Sapsucker (*Sphyrapicus ruber*), Blue Grouse, Varied Thrush, and Hermit Thrush (*Catharus guttatus*) to be important prey for Northern Goshawks nesting in inland parts of the Queen Charlotte Islands, and found no evidence of predation on crows. A possible explanation

may be that the Northwestern Crow occurs most abundantly near marine coasts and can become rare a few km inland (Campbell et al. 1997), and Beebe spent most of his field time along the coast. An analysis of 44 pellets collected from the base of nest trees on the Queen Charlotte Islands in 1996 showed that Red Squirrel (44%) and various songbirds (47%) were the major prey of nesting pairs during the breeding season (Roberts 1997).

On Vancouver Island, Red Squirrels may be the most important prey species, at least during early parts of the breeding season (McClaren 1997; T. Ethier, pers. comm.); other prey include Varied Thrush, Northern Flicker (*Colaptes auratus*), Red-breasted Sapsucker, Marbled Murrelets (*Brachyramphus marmoratus*) (T. Ethier, pers. comm.), and bats (J. Deal, pers. comm.).

Iverson et al. (1996) cautions that dietary studies emphasise the breeding season and that winter diet is poorly known. For *A. g. atricapillus*, winter diet is probably limited mainly to grouse, Snowshoe Hare, and Red Squirrel (Beebe 1974), and when food supplies become low, then migration may occur to areas where more plentiful or diverse prey exist. For *A. g. laingi*, which apparently does not migrate, common summer prey such as Steller's Jay and Varied Thrush may be rare in winter, and others such as Sharp-shinned Hawks are rare or absent (Iverson et al. 1996). Important winter prey for this subspecies may be Red Squirrel, ptarmigan and grouse (E. McClaren, pers. comm.).

Populations are regulated by several factors but are probably strongly regulated by food availability (McGowan 1975; Linden and Wikman 1983; Widen 1989; Doyle and Smith 1994;; Crocker-Bedford 1998; T. Ethier, pers. comm.) and predation (Ward and Kennedy 1996). Evidence for *A. g. laingi*, shows that of the ten most common prey species of goshawks in southeast Alaska, none are expected to benefit from clearcut logging and most will suffer declines (Iverson et al. 1996). Prey availability (forest structure for hunting) is often more important than prey abundance (Widen 1989;: Beier and Drennan 1997; Crocker-Bedford 1998). This has elevated the idea of management of habitat for goshawk prey species to about the same level as management for nesting habitat (Iverson et al. 1996; Widen 1997). This approach is favoured by Crocker-Bedford (1990a), who speculates that reduced re-occupancy at protected nest stands following the removal of trees from the surrounding landscape is attributable to a reduction in suitable prey habitat and accessibility, and hence a reduction in foraging opportunity. Breeding pair density may depend on the amount of habitat where suitable prey is more abundant than some threshold, and is accessible enough that the chance of capture in the habitat is worth the time and energy expended (Crocker-Bedford 1998). Habitat enhancement techniques in second-growth forests can be used to reduce the impact of logging on prey populations (J. Deal, pers. comm.), but such treatments are at the discretion of the forest licencee, private landowner, or Ministry of Forests.

2.3 Potential Threats to the Viability of Northern Goshawk Populations

2.3.1 Factors affecting Northern Goshawk habitats

Breeding habitat loss or fragmentation is the single most significant threat to the long-term viability of the Northern Goshawk in British Columbia, as it reduces the availability of suitable nesting habitat and the availability of preferred prey. Although data on large-scale population trends are equivocal, many studies have concluded that logging activities, especially clearcut logging, can adversely affect goshawks (Hennessy 1978; Reynolds and Wight 1978; Reynolds et al. 1982, 1992; Moore and Henry 1983; Hall 1984; Mannan and Meslow 1984; Crocker-Bedford and Chaney 1988; Reynolds 1989; Crocker-Bedford 1990a, 1994, 1998; Patla 1990, 1991; Marshall 1992; Austin 1993; Harris et al. 1994; see references in Block et al. 1994; see references in Duncan and Kirk 1995; Iverson et al. 1996); and can lead to local extirpation when the extent of logging is great (Petty 1989; Kenward et al. 1991 in Crocker-Bedford 1994; Crocker-Bedford 1998).

Because large-volume stands have high economic value and are also preferred as nesting habitat by goshawks, (see above discussion) logging is usually concentrated in forests with the highest quality goshawk habitat. Typical forestry practices such as partial cutting, understorey brushing, patch cutting and clear-cutting, result in a reduction in stem density and canopy volume, which reduces current habitat quality for nesting or foraging (Crocker-Bedford 1990b; Iverson et al. 1996). Therefore, logging may reduce the ability of a landscape to provide a suitable mixture of structural habitat attributes needed by goshawks, although individual logged areas may recover over time as suitable habitat. It is hypothesised that the cumulative effect of logging may result in fewer pairs, less opportunity to locate a new mate, higher proportions of habitat unoccupancy (Crocker-Bedford 1994), and larger home ranges (Crocker-Bedford 1998).

In coastal British Columbia, second-growth stands on good growing sites can become suitable for nesting *A. g. laingi* after 40-60 years, as several nests have been

found in such stands on Vancouver Island (D. Doyle, pers. comm.). If logging rotations of 100 years were standard, then provision of extensive amounts of suitable breeding habitat could be ensured. However, it is becoming increasingly common for second-growth stands that are younger than 100 years and which have size and structure suitable for goshawks, to be logged because of the timber values represented by trees of that size. The result is that, once a stand is logged, it may be continually logged just as it is becoming suitable for goshawks. In such a scenario, these stands would never recover sufficiently to provide habitat suitable for nesting goshawks, making the preservation of conservation areas a critical necessity for conservation of the species.

Logging in important foraging habitat likely has effects disproportionate to the size of the habitat; on the other hand, logging that misses important foraging habitat may have little or no effect on home range size or breeding density (Crocker-Bedford 1998). It may be possible, in managed forests with certain forest types, to improve habitat for goshawks through careful treatments using standard forest harvesting techniques (Reynolds et al. 1992, pers. comm.).

Goshawks are, at times, sensitive to disturbance at or near the nest, and may abandon a nest during incubation or even when nestlings are present, if disturbed by industrial activity, or other human presence (Speiser and Bosakowski 1987; Reynolds 1989; Speiser 1992; Boal and Mannan 1994; Squires and Reynolds 1997). In the Cariboo Region of British Columbia, seven of eight nests (only 3 active nests) were in unmanaged stands but logged areas or active logging were located nearby. It was thought that all nests existed before the nearby road-building or logging had occurred (Bosakowski and Rithaler 1997). One Cariboo nest successfully fledged young in 1996, even though logging and road-building occurred nearby during the nesting season. A 1.4 ha reserve was placed around the nest and, in 1997, this nest appeared to be active (J. Steciw, pers. comm.), suggesting tolerance to some level of disturbance. In Arizona, noise from logging trucks passing by about 500 m from 2 active nests elicited no discernible response from a brooding adult female or a lone juvenile (Grubb et al. 1998).

Livestock grazing may be a source of habitat deterioration, depending on its intensity (Reynolds 1989; Marshall 1992). When concentrated and long-term, grazing can effectively prevent understorey development such that deciduous overstorey does not regenerate, and prey species lose crucial habitat cover. This factor has not been evaluated in British Columbia, and while not likely to provide the same level of threat as logging activities, may be important locally where cattle ranches are concentrated. Fire suppression, which results in litter accumulation and the development of overly dense understoreys, can reduce hunting success by goshawks. This is also cited as a threat to goshawk habitat in some areas (Marshall 1992; Reynolds et al. 1992). Fire suppression in grasslands, however, allows coniferous forest to expand which ultimately increases potential goshawk habitat.

2.3.2 Competition and predation

The Northern Goshawk is aggressive towards other goshawks and other raptors, especially during the breeding season. It will readily attack and occasionally kill raptors such as Red-tailed Hawk, Great Horned Owl, and Long-eared Owl (*Asio otus*) when they come near nests (Beebe 1974; Kostrzewa 1991). In southeast Alaska, Sharp-shinned Hawks are regularly taken as prey by nesting goshawks (Iverson et al. 1996). In turn, the Great Horned Owl and a few other raptors kill goshawks (Schuster 1977; Moore and Henry 1983). Siblicide and cannibalism are known to occur (Boal and Bacorn 1994). A number of mammalian predators that destroy nestlings or eggs have been identified; including Wolverine, Fisher, Marten (*Martes americanus*) and Raccoon (Paragi and Wholecheese 1994; Doyle 1995; Duncan and Kirk 1995; Erdmann et al. 1998). In southeast Alaska, some suitable habitat was not used by nesting goshawks, possibly because of the presence of nesting Bald Eagles (*Haliaeetus leucocephalus*) (Iverson et al. 1996).

Northern Goshawk nests tend to be well spaced through suitable habitat on a large scale, with average inter-nest distances ranging from 3.0 km in Arizona (Reynolds et al. 1992; Reynolds and Joy 1998) to 5.6 km in Oregon (Reynolds and Wight 1978). On northern Vancouver Island, a subset of 12 nests averaged 8.7 km apart (McClaren 1998); in the Kispiox Forest District, nests appear to be about 20 km apart (T. Mahon, pers. comm.). In Arizona, other nesting raptors seem to be excluded from within 1 km of a goshawk nest (Crocker-Bedford 1990). However, elsewhere, active goshawk nests have been observed within 100 m of a variety of nesting raptors; including Cooper's Hawk (*Accipiter cooperii*), Sharp-shinned Hawk, Great Horned Owl, Great Gray Owl (*Strix nebulosa*), Spotted Owl (*Strix occidentalis*), Red-tailed Hawk and Bald Eagle (Moore and Henry 1983; Patla 1991 in Marshall 1992; Marshall 1992).

Inter- and intraspecific competition for nesting habitat occurs. Removal of forest habitat around nest sites reduces canopy protection, and increases predation

and competition with open habitat-adapted species (Hennessy 1978; Reynolds et al. 1982; Moore and Henry 1983; Crocker-Bedford 1990a; Woodbridge and Detrich 1994; E. McClaren, pers. comm.). These studies showed that Northern Goshawk nests have been taken over by Red-tailed Hawks, Great Horned Owls, Great Gray Owls, Barred Owls (*Strix varia*) and Long-eared Owls following fragmentation of goshawk habitat

Populations may be limited by predation, however, this is unlikely in most regions. A long-term study in northeastern Wisconsin speculated that predation by Fisher was depressing a population of goshawks (Erdman et al. 1998). In Arizona, Great Horned Owl predation was the most important source of nestling mortality (Boal and Mannan 1994); but few Great Horned Owls occur in the southeast Alaska range of *A. g. laingi*, for example, and should have little impact there (Iverson et al. 1996). The Great Horned Owl does not occur on the Queen Charlotte Islands, but is fairly common in parts of Vancouver Island (Campbell et al. 1990). Ward and Kennedy (1996) found that nestling mortality was significantly reduced when prey was more abundant near the nest (dead quail were offered as a food supplement); apparently affording the female goshawk more time to defend nestlings and fledglings.

2.3.3 Disease and pesticides

No studies have specifically addressed the impact of disease on Northern Goshawk populations, but it is thought to be insignificant (McGowan 1975; Duncan and Kirk 1995). Frounce, a lethal disease caused by *Trichmonas gallinae*, can be contracted by eating infected individuals of the pigeon and dove family (Columbidae), particularly the Rock Dove (*Columba livia*). Beebe (1974) suggested that goshawks in contact with Mourning Dove (*Zenaida macroura*) or Band-tailed Pigeon (*Columba fasciata*) had developed resistance to the disease, but that northern populations had not. Given that goshawks easily catch and kill Rock Doves and, once infected, usually die within three weeks, Beebe worried that northern migrants would suffer high mortality if wintering in areas with Rock Doves. This concern has not yet been evaluated.

Rotation among alternative nests within territories is believed to reduce parasite loading, thus increasing survival rates. This further emphasises the importance of the availability of multiple nest sites (T. Ethier, pers. comm.). Although traces of pesticides have been found in most eggs analysed, levels are low (Snyder et al. 1973). The prey preferences of this species reduce its risk of being impacted by pesticides (Reynolds and Wight 1978; Squires and Reynolds 1997); although this may have been a significant problem in Europe (Widen 1997).

2.3.4 Commercial use and human persecution

The Northern Goshawk has no known subsistence value, and there is little commercial market in North America beyond a small coterie of licensed falconers. In British Columbia, falconers may take a small number of free-flying immature birds or nestlings of *A. g. atricapillus* under permit (M. Chutter, pers. comm.). Mandatory reporting of harvest shows between 0 and 5 currently taken per year. Although the effects of falconry are considered to be negligible, as of 1 May 1994, following its designation to the provincial Red-list, *A. g. laingi* can no longer be legally harvested on Vancouver Island or in any other parts of Region 1, nor on the Queen Charlotte Islands in Region 6. This restriction was enacted in keeping with the Wildlife Branch policy of non-harvest of Threatened or Endangered taxa.

Shooting of goshawks is a significant problem in Europe, but is not a significant cause of mortality in North America (Squires and Reynolds 1997). However, in local areas where populations are very low, such as on the Queen Charlotte Islands, and where goshawks tend to show up in winter at backyard chicken coops, the possibility of shooting is more of a concern than elsewhere in the province (P. Chytyk, pers. comm.).

2.4 Current Conservation Actions

2.4.1 Legal considerations

The *Wildlife Act* of British Columbia, section 34, protects Northern Goshawks, their eggs, nestlings, and their nests when the nests are occupied. A nest is considered occupied from the time it is under construction to when fledglings leave the nest. A *"nest"* is defined as a structure, or part of a structure, prepared by or used by an animal of the class *Aves* to hold its eggs or offspring.

Persecution (shooting, trapping, poisoning or any other measure of killing) of goshawks in British Columbia is illegal under section 34 of the *Wildlife Act*, though allowances can be made when domestic animals are being defended. Current penalties for conviction for offences under section 34 include a fine of up to $50,000 and six months in jail for a first offence. In addition, "creative sentencing" options available to the judge can include the prohibition of a person from continuing any actions that could result in repetition of the offence, directing the person to take appropriate action to remedy

or avoid any harm to the environment or wildlife, payment of compensation in whole or in part for any remedial action necessary, the performance of community service, payment of appropriate amounts of money directly to provincial environmental protection programs, and additional fines if the court is satisfied that the perpetrator received a monetary benefit from the offence (M. Chutter, pers. comm.).

Federal endangered species legislation is currently being developed. The National Accord for the Protection of Species at Risk has been signed by most of the provinces as of the spring of 1998. It states that any province that signs on to the accord commits to developing complementary programs or legislation to meet all the areas listed on the accord. This includes protection of Threatened and Endangered species and their habitat. The Forest Practices Code has several legal components for the protection of species at risk. Among them are legally established management practises designed to protect critical or limiting habitat of certain species at risk that have been signed off as Identified Wildlife (Province of British Columbia 1999a) by the Chief Forester and the Deputy Minister of Environment, Lands and Parks (Sections 70 Operational Planning Regulation, B.C. Reg. 107/98).

2.4.2 Research efforts in British Columbia

Recently, efforts have been made to increase the number of known nesting locations, and collect data on a number of life history and habitat parameters. Inventories have been conducted on Vancouver Island (1994 to 1999), the Queen Charlotte Islands (1995 to 1999), the Kispiox Forest District (near Smithers) (1996 to 1999), the Peace Sub-region (1997 and 1998) and the Cariboo-Chilcotin-area (1996 to 1997). Inventory on the Queen Charlotte Islands has been relatively less-intensive than on Vancouver Island, and has been restricted to only one ecosection, the Skidegate Plateau.

In addition, locations of Northern Goshawk nests are being collected from smaller inventory projects (e.g., Kootenay Region) or other more general wildlife surveys such as those related to Terrestrial Ecosystem Mapping projects. Inventory data are being accumulated and synthesised by various MELP biologists and the B.C. Conservation Data Centre (CDC). Funding for these projects has largely been from Forest Renewal B.C. (FRBC), and Habitat Conservation Trust Fund (HCTF).

A group of goshawk researchers met in Victoria in late February, 1998, to discuss research priorities and techniques and to find ways to share costs and innovations. It was a successful gathering and interest was expressed in having regular meetings to share knowledge amongst members of the group. Though no follow-up meetings have taken place, due to logistical constraints, many of the group members continue to exchange information via other channels.

2.4.3 Protected Areas Strategy for British Columbia

British Columbia's Protected Areas Strategy (PAS) describes the provincial government's policies and processes to protect 12% of the province. The strategy aims to protect viable, representative examples of the natural diversity in B.C., and to protect special natural, cultural heritage and recreational features (Lewis and Westmacott 1996).

PAS distributes fully protected areas (national parks and reserves, Class A and C provincial parks, ecological reserves and wilderness conservancies), and areas allowing restricted industrial activity (provincial recreation areas and forest wilderness areas) according to an ecological framework combining the ecoregion classification system and the biogeoclimatic ecosystem classification. The strategy stresses both representation of the range of ecosystem types across B.C., and geographic distribution of a system of protected areas.

As of 1998, 8% of the forested area in the province had some form of protected status. Within the range of *A. g. laingi* on Vancouver Island, 11.8% of the forested land base was protected and on the Queen Charlotte Islands, 22.4% of the forested land base was protected. Table 1 shows the split in these areas between high elevation forests (Mountain Hemlock biogeoclimatic Zone) and the low elevation forests where most Northern Goshawk nests have been found (Coastal Western Hemlock and Coastal Douglas-fir biogeoclimatic zones).

2.4.4 Forest Practices Code

The *Forest Practices Code of British Columbia Act*, Strategic and Operational Planning Regulations establish a legal framework for managing biological diversity in British Columbia on Crown Lands administered by the Ministry of Forests.

The Biodiversity Guidebook (Province of British Columbia 1995a) outlines the application of biodiversity emphasis options to landscape units, and the establishment of landscape unit objectives based on natural disturbance types (NDTs) occurring in B.C. (see section 3.1.1). Key management species considerations are among the criteria for assigning biodiversity emphasis options. On a regional or sub-regional planning level,

Table 1. Percentage of forests in protected areas on Vancouver Island and the Queen Charlotte Islands [data from B.C. Ministry of Forests (MOF) and B.C. Land Use Coordination Office (LUCO)*].

	% of forested land base in protected areas (all BEC zones)	% of low elevation (CDF, CWH) forested land base in protected areas	% of high elevation (MH) forested land base in protected areas
Vancouver Island	11.8	9.8	28
Queen Charlotte Islands	22.4	23	16.8

*These data were derived from an interpretation of the biogeoclimatic units that are predominately forested (Del Meidinger, MOF Research Branch, pers. comm.) overlayed with the protected areas (from LUCO).

the guidebook recommends 30-55% (revised by Chief Forester policy to 45%) of the area be the lower biodiversity emphasis option, 35-60% (revised by Chief Forester policy to 45%) as intermediate biodiversity emphasis, and that 10% be designated as the higher biodiversity emphasis option. Old forest retention requirements for each biodiversity emphasis option have been suggested for each natural disturbance regime (Table 2). NDTs are naturally-occurring events such as fire, disease, or insect outbreak that destroy a stand periodically. There are four forested NDTs described for British Columbia (B.C. Government 1995). NDT 1 is defined as ecosystems with rare stand-initiating events (e.g., mean disturbance return interval of 250 years for wet CWH and ICH forests-to 350 years for wet ESSF and MH forests). NDT 2 are ecosystems with infrequent stand-initiating events (mean disturbance return interval of 200 years, often larger fires that occurred after extended droughts). NDT 3 are ecosystems with frequent stand-initiating events (mean disturbance return interval is 100 – 150 years, more frequent fires than NDT 2, and also frequent outbreaks of defoliating insects and root diseases). NDT 4 are ecosystems with frequent stand-maintaining fires (surface fire return intervals from 4 – 50 years and crown fire intervals of 150 – 250 years, in dry forests and grasslands).

Table 2. Biodiversity Guidebook recommendations for old forest representation by natural disturbance type and biodiversity emphasis option*.

Natural Disturbance Type*	Old Forest Representation (% of landscape unit) Biodiversity Emphasis Option**		
	Low	Intermediate	High
1	13 - 19	13 - 19	19 - 28
2	9	9	13
3	7 - 14	7 - 14	10 - 21
4	13	13	19

*1 – ecosystems with rare stand-initiating events; 2 – ecosystems with infrequent stand-initiating events; 3 – ecosystems with frequent stand-initiating events; 4 – ecosystems with frequent stand-maintaining fires.

**The ranges represent values for different biogeoclimatic units. For more detailed tables and information readers should consult the Biodiversity Guidebook (Province of British Columbia 1995a) or the Landscape Unit Planning Guide (Province of British Columbia 1999b).

Since old forest retention recommendations are specified for dominant forest covers within natural disturbance types, landscape units can potentially be managed for the retention of suitable Northern Goshawk habitat, if habitat requirements within a variety of forest types are sufficiently defined.

The use of riparian management areas (RMAs), wildlife tree patches (WTPs), ungulate winter ranges (UWRs), sensitive areas, and management for vegetative species composition and coarse woody debris, present additional opportunity to protect goshawk nest sites and suitable habitat (see section 3.1 for more description of RMAs and WTPs).

Both *A. g. laingi* and *A. g. atricapillus*, have been "identified" by the Chief Forester and the Deputy Minister of Environment, Lands and Parks as requiring special attention under the Forest Practices Code. As Identified Wildlife, the Northern Goshawk is part of the Identified Wildlife Management Strategy (IWMS) (Province of British Columbia 1999a). This strategy contains specific management practices referred to as General Wildlife Measures (GWMs) that outline what forest and range practices can occur within designated species-specific conservation areas called Wildlife Habitat Areas (WHAs). However, IWMS is limited by an overall 1% maximum provincial impact on short- and long- term timber supply. For *A. g. laingi* the establishment of a "three-tiered" WHA (total 2400 ha) at selected breeding sites and associated foraging areas is recommended. Three suitable and three replacement nest areas of 12 ha each are restricted from any forest practices (Reynolds et al. 1992). Limited timber harvesting is permitted within the rest of the WHA during specified times (outside the period of courtship and nesting for active nests) and in a manner that adheres to a specified distribution of seral stages. This distribution includes 20% closed canopy old forest, 40% mature forest and not more than 20% young forest. The definition of young, mature and old forests varies with natural disturbance type and biogeoclimatic zone. All definitions can be found in the Biodiversity Guidebook (Province of British Columbia 1995a).

The recommended WHA for *A. g. atricapillus* is described as a 240 ha area including three 12 ha nest areas. This WHA is smaller than for *A. g. laingi* because biological assessment of *A. g. atricapillus* considered it not to be at risk. Like the *A. g. laingi* WHA, no forest practices are permitted in nest areas, but limited timber extraction can take place within the rest of the WHA during specified times of year. For a WHA to be designated, a nest site must have been active within five years and the WHA approved by the Chief Forester and Deputy Minister of Environment, Lands and Parks.

The 1% threshold on timber supply impact for the application of WHAs and their associated practises will prevent the unlimited application of both the *A. g. atricapillus* and the *A. g. laingi* WHAs. Initially, this threshold will be applied on a forest district basis, but after two years it will be redistributed provincially based on species' needs and other factors. This may enable a rearrangement of the forest district pe centages to allow more goshawk WHAs to be established in coastal forests in the range of A.g. laingi, while still staying within the overall provincial 1% limit.

The IWMS states that landscape units with suitable goshawk habitat should be considered for the high biodiversity emphasis option. The seral stage distribution suggested for this emphasis option has the highest proportion of old forest and is most likely to protect suitable goshawk habitat.

3 HABITAT MANAGEMENT OPTIONS

Management tools for Northern Goshawk habitat may be found in the Protected Areas Strategy (Lewis and Westmacott 1996), the *Forest Practices Code of British Columbia Act*, and in recommendations from local planning tables. Within this framework there is room for flexibility, adaptive management, and future changes generated by research.

3.1 Forest Practices Code

The Forest Practices Code (FPC) has a number of regulations and guidelines that are designed to protect habitat for the wildlife species of British Columbia (Province of British Columbia 1999a). The effectiveness of the FPC cannot be determined until all aspects of it are fully implemented, monitored and assessed. Although the FPC has been in effect since 1995, the landscape level features of the Biodiversity Guidebook (Province of British Columbia 1995a), implemented through the Landscape Unit Planning Guide (Province of British Columbia 1999b), and the specific recommendations for Northern Goshawks in the Identified Wildlife Management Strategy (IWMS) (Province of British Columbia 1999a), are just beginning to be implemented. The IWMS was released in February 1999. These FPC documents contain legally enforceable measures that have the highest probability of conserving habitat for Northern Goshawks.

The conservation initiatives recommended in this document rely on management tools that are in place

and feasible. The following is a list of mechanisms that could be used to protect Northern Goshawk habitat. There is no attempt in this document to recommend initiatives that are not currently feasible or available.

3.1.1 Landscape unit biodiversity management

Regional Landscape Unit Planning Strategies (RLUPS) have been prepared for each forest region that contain draft landscape unit boundaries and draft biodiversity emphasis assignments. Landscape unit implementation will be based on the Landscape Unit Planning Guide (Province of British Columbia 1999b). Only phase one biodiversity objectives (old-growth retention and wildlife trees) will be established. Consideration of goshawk habitat could be one of the criteria used when establishing biodiversity emphasis options and old-growth management areas (see Section 3.1.4).

3.1.2 Riparian Management Area

Streams are classified by: a) width; b) whether or not they are fish-bearing; and c) whether or not they occur in a community watershed. Lakes and wetlands are classified by area. The "riparian management area" refers to both a riparian reserve zone and a management zone. Reserve zones vary from 0 to 50 m and management zones vary from 20 – 40 m. All streams, wetlands and lakes have a management zone where silvicultural practices can occur as long as the management zone remains an effective buffer for the stream or reserve zone (where present). Only streams 1.5 – 100 m in width with fish or in a community watershed have a reserve zone that excludes activities (see Section 10 of the Timber Harvesting Practices Regulation).

When goshawk nest sites occur near these riparian areas, management options will include the leave strips already legislated. The best management practices for riparian management zones outlined in the Riparian Management Area Guidebook (Province of British Columbia 1995b) should be implemented under these circumstances.

3.1.3 Lake shore management area

Lake shore management areas are partially covered in the riparian management areas described above. In addition, all lakes that are >5 ha and <1000 ha are classified from A to E according to the criteria specified in regional Lake Classification and Lakeshore Management Guidebooks (Province of British Columbia 1996). Class A lakes have lake shore management zones in which little or no silviculture is allowed, while class E lakes allow up to 50% of the basal area to be removed. Classification depends in part on whether any Identified Wildlife use the lake or lake shore. Northern Goshawk nests that are found near a lake could influence the classification of the lake and result in more area left uncut in the vicinity of the nest.

3.1.4 Old-growth management area

Old-growth management areas (OGMAs) contain or are managed to replace specific structural old-growth attributes. They are mapped and treated as special management areas. These areas contribute to the seral stage retention objectives and can be as small as 2 ha. However, in order to include some interior habitat, it is thought that OGMAs must be a minimum of 36 ha, and with a circular or square shape to maximize the radius of the reserve. For example, a 36 ha rectangle that is long and thin would not provide interior stand conditions. (A. von Sacken, pers. comm). No harvesting is permitted within OGMAs.

3.1.5 Ungulate winter range

During the winter of 1997-98, the *Operational Planning Regulation* of the Forest Practices Code underwent modifications. One addition was ungulate winter range (section 69, OPR). The intent of these code changes is to take all pre-existing ungulate winter range agreements and grandfather them into the Forest Practices Code, and to create a process to bring new ungulate winter ranges under the code where approved. All the FPC ungulate winter ranges will be mapped. They could be areas of mature and old forest as these are important for winter survival of ungulates. These same areas could be prime Northern Goshawk range throughout the year. On Vancouver Island, 6 of the 34 known nests are on previously identified ungulate (4 in deer winter range and 2 in elk winter range) winter ranges (D. Doyle, pers. comm.).

3.1.6 Stand management

The Biodiversity Guidebook describes elements of stand management designed to maintain stand structure and hence, some aspects of biodiversity. These are wildlife trees (both live and standing dead), coarse woody debris, tree species diversity and understorey vegetation diver-

sity. Many of these stand level attributes will contribute to the maintenance of populations of prey species for Northern Goshawks.

3.1.7 Wildlife tree patch

A wildlife tree patch (WTP) can range from the size of 1 tree to several hectares. Any WTP over 2 ha will contribute to the old forest representation of the landscape unit. At the larger end of the spectrum and in the appropriate landscape context, WTPs can provide protection of a goshawk nest. Foraging areas would have to be available within the greater landscape area.

3.1.8 WHAs for other Identified Wildlife

Marbled Murrelet range overlaps part of the range of both subspecies of Northern Goshawk, but especially that of *A. g. laingi*. In fact, Marbled Murrelets have been found in the prey remains of Northern Goshawk on Vancouver Island (T. Ethier, unpubl. data) and in SE Alaska (Iverson et al. 1996). Marbled Murrelet WHAs are relatively large areas of old forest, some or all of which may be suitable habitat for goshawks. WHAs that are established for other species at risk, such as Keen's Long-eared Myotis (*Myotis keenii*), would also likely conserve habitat suitable for goshawks. Some of the coastal plant community WHAs may also overlap with Northern Goshawk habitat, but they are generally too small to be significant alone for goshawks.

3.1.9 Special resource management zones

Some wildlife with very special habitat management requirements (e.g., Spotted Owl) may have large Special Resource Management Zones established for conservation purposes. Such reserves could be very useful for conservation of Northern Goshawk habitat as well.

3.1.10 Identified Wildlife designation

Both subspecies of Northern Goshawk, were declared Identified Wildlife by the Chief Forester and the Deputy Minister of Environment, Lands and Parks in 1999. This status results in special management attention under the Forest Practices Code.

- The possibility of wildlife habitat areas and their accompanying general wildlife measures for the express purpose of protecting limiting habitat for goshawks is enabled by this designation (Section 70 Operational Planning Regulation: Identified Wildlife Management Strategy). However, over the first 2 years, only a maximum of 1% of mature harvestable timber may be removed from industrial use per forest district for Identified Wildlife which, given the area of goshawk WHAs, severely restricts the number of goshawk WHAs that could be established.
- When classifying lakes, the greatest levels of protection should be provided for Identified Wildlife that occupy lakes or lake shores (Lake Classification and Lakeshore Management Guidebooks).

3.1.11 Wildlife habitat feature

A wildlife habitat feature can be any feature agreed to by the Ministry of Forests district manager and a designated environment official. Active nest sites for birds that occur in forested areas that are already designated as wildlife habitat features include those of Bald Eagle, Osprey or Great Blue Heron; however, any district can designate Northern Goshawk nests as a wildlife habitat feature by agreement of the Ministry of Forests district manager and a designated environment official. This designation may allow a buffer zone to be negotiated around the nest tree which is already protected by Section 34 of the *Wildlife Act* during the time the nest is active.

3.1.12 Sensitive areas

Lands that are deemed environmentally sensitive can be set aside under the FPC. These reserves can be relatively large, about 1000 ha in size, and could potentially include habitat suitable for Northern Goshawks.

3.1.13 Landscape connectivity

Landscape connectivity strategies are specified for each natural disturbance type. Connectivity involves the wise placement of OGMAs, the use of riparian areas and the design created though harvesting patterns within each landscape unit. Landscape connectivity is important to Northern Goshawks because they are sensitive to fragmentation between nesting and foraging habitat. Widen (1989) found that, in Sweden, mature forest stands larger than 40 ha were ten times more preferred on a per hectare basis than mature stands smaller than 20 ha. In southeast Alaska, reserves are considered to be one component of a management strategy that must link reserves, with extended harvest rotations, management of the intervening forest matrix, and extended buffers (K. Titus, pers. comm.); in other words, more connectivity.

3.1.14 Higher level plan recommendations (Resource management zone objectives)

Areas of importance to a species or group of species may be designated for special management by a Higher Level Planning table. A resource management zone objective that is signed approved by three ministers (Minister of Forests, Minister of Environment, Lands and Parks, Minister of Energy and Mines) is considered a Higher Level Plan under the Identified Wildlife Management Strategy. These plans take precedence over existing forest and range management plans.

Currently, the government does not recommend that Northern Goshawks be considered during Higher Level Plan deliberations until the effects of the existing Identified Wildlife Management Strategy for them has been evaluated. In this regard, government will prepare a Conservation Assessment, examining the spatial arrangement of all existing habitat designations that manage goshawk habitat. If this assessment concludes that the species is not being adequately managed under the current provisions of the code, government may include Northern Goshawk as a Higher Level Plan species. However, any non-government member of an LRMP table can bring goshawks forward for High Level Plan consideration.

Resource management zone objectives for planning areas with an emphasis on Northern Goshawk management should include riparian buffers in the vicinity of productive nesting habitat, increased mature and old forest retention across the planning area and connectivity of old and mature forest throughout the planning area.

3.2 Land and Resource Management Plans (LRMP)

The Land and Resource Management Planning (LRMP) process is the sub-regional, integrated resource planning process for British Columbia. It promotes decision making on the basis of the principles of sustainability and consensus. It requires that the public and major stakeholders have the opportunity to participate in all steps of the process. Land and resource decisions formerly made unilaterally by single government agencies are being replaced by inter-agency processes that seek to consider all environmental, resource and socio-economic values. Decisions with short-range perspectives are being replaced by decisions that seek to protect future generations by ensuring commitments of land and resources are sustainable in the long term. Planning decisions made through internal government agency processes are being replaced by decisions made through open, consensus-based processes involving full participation of the public and stakeholders (www.luco.gov.bc.ca/lrmp). Resource management objectives are set by LRMP planning tables.

4 CONSERVATION INITIATIVE

4.1 Conservation Objective

The conservation objective for the Northern Goshawk in British Columbia is to maintain or enhance wild populations, well-distributed throughout their range, to a level that permits the removal of the at-risk status for *A. g. laingi* and prevents the attainment of at-risk status for *A. g. atricapillus*. (M. Chutter, pers. comm.). At-risk status is determined by the Conservation Data Centre, based on the internationally accepted criteria of provincial abundance, estimated occurrences, range, trends, protected occurrences and threats.

4.2 Management Priorities

Both federal and provincial ranking and research throughout North America point to a different management approach for the two recognised subspecies in British Columbia. COSEWIC ranks *A. g. atricapillus* as Not At Risk, while *A. g. laingi* is ranked Vulnerable. In British Columbia, the Yellow-listed *A. g. atricapillus* is ranked by the CDC as S4 (apparently secure); while the Red-listed *A. g. laingi* is ranked S2 (potential for extirpation exists). Due to recent inventory in coastal British Columbia that has shown low numbers of breeding pairs of *A. g. laingi*, the Wildlife Branch is considering the preparation of a new COSEWIC status report.

The coastal or insular subspecies, *A. g. laingi*, has been the subject of much research in the last few years and its small populations and strong preference for old forests have been documented (Iverson et al. 1996; Chytyk and Dhanwant 1997; Chytyk et al. 1997; Ethier 1997; McClaren 1997, 1998). Simultaneously, the loss of old forests on the Queen Charlotte Islands and Vancouver Island continues at rates that are known to be non-sustainable (Iverson et al. 1996; Pearce 1999). Mature second growth stands, which can provide suitable nesting habitat, also are increasingly being harvested as old-growth stands become less available.

Within the range of *A. g. laingi*, individuals on the Queen Charlotte Islands exhibit the most extreme forms of colour and size (Whaley and White 1994; Flatten et al. 1998), and appear to occur at the lowest densities (Chytyk and Dhanwant 1997; Chytyk et al. 1997). Because this population has the least opportunity for dispersal and gene flow between the coastal mainland

or Vancouver Island, it is the most distinctive and should receive the highest priority for conservation efforts. Populations of *A. g. laingi* on Vancouver Island should receive the second highest priority for goshawk conservation efforts in British Columbia, since Vancouver Island holds the bulk of the provincial population of that "at risk" subspecies.

A recent review of the published and, unpublished demographic data on *A. g. atricapillus* throughout North America concluded that there is no statistical evidence that this subspecies is declining (Kennedy 1997); however, Crocker-Bedford (1998) and Smallwood (1998) have questioned the utility and validity of Kennedy's analysis and Kennedy (pers. comm.) herself believes that declines have occurred. Although this subspecies is: 1) is widely distributed in British Columbia throughout forested parts of the mainland; 2) is not considered at risk in Canada (Duncan and Kirk 1995), and 3) is not considered at risk in British Columbia (Fraser et al. 1999), it has been designated as Identified Wildlife under the Forest Practices Code. Identified Wildlife status is possible for Yellow-listed (not at risk) species of regional concern that are affected by forest or range activities and are not adequately managed by the Biodiversity or Riparian Management Area Guidebooks. Although Identified Wildlife are given high conservation priority, and all goshawks are affected by forestry activities, *A. g. atricapillus* is not currently considered at risk on a provincial scale and should, therefore, be given a lower conservation priority than *A. g. laingi*. Identified Wildlife status was given to *A. g. atricapillus* to prevent it from becoming at risk in the province under current forestry practices.

The following subsections weigh the differences between the two subspecies in risk of extirpation due to human activities and are designed to fit within the current management framework. It is imperative that this level of protection be monitored and its effectiveness evaluated so that modifications can be made, if necessary.

4.3 Landscape Level Management

Because the Northern Goshawk is a species that uses the landscape at a scale comparable to the landscape unit planning scale, it is important to use all available landscape level tools to maintain appropriate levels of unfragmented habitat for this species. These tools include, but are not limited to, protected areas, riparian reserves and to some extent riparian management zones, any special management areas such as the Spotted Owl management areas, ungulate winter ranges, areas retained for old seral stage distribution (old-growth management areas) and other reserved areas.

Management efforts must be coordinated from the landscape level, for both subspecies, and any WHA designations should be made within the context of the distribution of protected old or mature forest habitat over the landscape.

4.4 Mapping

Each subregional area should create a planning map showing all protected areas, riparian reserve areas, ungulate winter ranges, OGMAs, inoperable areas and any other areas netted out of the timber harvesting land base. This can be overlaid on a map showing habitat suitability for the Northern Goshawk. In the absence of analysis of habitat suitability, a forest cover map can be used that shows mature and old forest.

Habitat suitability/capability mapping has recently become a popular and less expensive management tool for forest managers, in lieu of more costly field surveys for nests. For example, an algorithm for habitat suitability has been developed for the Kispiox Forest District (Turney and Mahon 1997). Other habitat suitability models for goshawks in British Columbia have been developed for the Skidegate Plateau on the Queen Charlotte Islands (Chytyk and Cooper 1999), the Kispiox Forest District (Cooper and Chytyk 1999), parts of the Dawson Creek Forest District (Saxena and Bilyk 1999), and Okanagan (author unknown). Other models for goshawk habitat outside of B.C. have been developed by Lengas and Roberts (no date), Hayward et al. (1983), Warren et al (1990), Lilieholm et al. (1993), Johansson et al. (1994), Schaffer et al. (1995) (for Foothills Model Forest, Alberta), Titus et al. (1995), and Csuti et al. (1997). These models could be used as a starting point for the development of appropriate habitat suitability mapping for other subregional areas.

Habitat suitability mapping may lead to more efficient surveys for nests. For example, in the Invermere Forest District, potential goshawk nesting habitat was mapped using suitable habitat criteria and the highest potential habitat was surveyed for nests (Machmer et al. 1999). During this study, several nests were found in only a few days of surveys; a much higher rate of finding nests than occurs with randomized sampling effort. This suggests that during the early phase of the conservation initiative, when funding is limited and finding nests is a priority, any tools that have the potential to effectively increase efficiency should be investigated and used accordingly. However, in most areas of the province,

including the Queen Charlotte Islands, there are insufficient empirical data to confidently stratify potential breeding habitat, and random sampling should be encouraged when feasible.

Known nest sites, both occupied and unoccupied should be marked on the planning map as these represent the areas where a WHA can potentially be placed. Choices between nest areas and determination of the size of nest areas should be made primarily on the basis of the overall fragmentation of the landscape, however, another consideration may be whether the site has multiple nests or a single nest. In the Yukon, the multi-nest sites were more persistent than the single nest sites during years when the prey base was limiting (Frank Doyle, pers. comm.).

These planning maps should also show where goshawk surveys have been conducted to help put known nest sites and future research and survey efforts in context.

4.5 Identified Wildlife Management Strategy for *A. g. atricapillus*

The planning map will indicate the areas with large, unfragmented suitable habitat and those that are more fragmented. Judicious placing of WHAs will increase the size of previously constrained areas or connect two habitat fragments. As currently written, a WHA should be about 240 ha in size and include nest areas and the post-fledgling area' however, in some cases, smaller WHA's may be justified. Note that smaller reserves may be inadequate to maintain a breeding pair if adjacent habitat is of poor quality. WHAs must be established within the context of a landscape-level wildlife habitat plan. Therefore it is clear that WHAs should be used as a component of a landscape plan rather than as the only mechanism for the protection of the subspecies.

4.6 Identified Wildlife Management Strategy for *A. g. laingi*

Emphasis is placed on *A. g. laingi* within the IWMS, and allows for significantly more operable timber to be set aside for this subspecies. The IWMS describes a WHA for this subspecies as a 2400 ha area with some limited timber harvesting allowed which will reduce the number of hectares actually removed from the timber harvesting land base. This may be further reduced by the overlap of a WHA location on a previously constrained area such as a Marbled Murrelet WHA, a riparian reserve zone, an old-growth management area, an ungulate winter range, or any other protected area designation.

The authors recommend that as close to a full 2400 ha area as possible be designated for each WHA with some exceptions in areas where the background matrix has a high component of mature and old forest. This is most likely attainable in landscape units with high biodiversity emphasis. However, the 1% threshold by forest district of land removal from harvesting may create situations in which wildlife managers have to choose between protecting only one or two goshawk nests sites with full-sized WHAs, versus trying to protect more sites with areas smaller than what the existing IWMS guidelines advocate. In such situations, consideration will have to be given as to whether protecting more nests and post-fledging areas should take precedence over protecting foraging areas. As a short term strategy, at least until the 1% threshold per forest district is re-assessed, the authors believe that it may be more practical to establish smaller WHAs around more nests than larger WHAs around fewer nests. Where feasible, such smaller WHAs should include at least 240 ha of contiguous suitable habitat around a nest site in order to maintain an intact post-fledging area. It should be noted that the suggestion is not that WHAs smaller than 2400 ha are sufficient to conserve *A.g. laingi*, only that in some cases, preserving several smaller WHAs may be more practical than preserving one large one, and the option should be available for consideration. In fact, the authors strongly recommend that all *A.g.laingi* WHAs, especially those less than 2400 ha, should be monitored for activity and productivity over time in order to assess the success of various sized reserves.

The general wildlife measures (GWMs) for *A. g. laingi* specify a seral stage distribution that leaves 20% of the 2400 ha WHA in old forest with an additional 40% in mature forest (or old forest if mature forest is not available). The definitions of old forest and mature forest follow the Biodiversity Guidebook where old forest in the CWH is >250 years and mature forest is >80 years. Acknowledging that goshawk habitat in British Columbia and Alaska may differ to some degree, caution is suggested in applying the 20% old forest requirement to the WHA. In a study by Iverson et al. (1996), forests with less than 23% or 28% old forest, depending on the sex of the goshawks, were not used. The average proportion of old forest in a goshawk use area was 43% with a standard deviation of 15% (Iverson et al. 1996). Iverson et al. (1996) considered that half the goshawk population would be lost if the forest cover dropped below 43% old forest. However, several nests on Vancouver Island have been found in second-growth stands, which suggests that stands >60 years may be suitable in some situations.

Redistribution between districts of the hectares available for WHAs could be done on the basis of population density (number of nest sites for a specific survey effort), available habitat, risk to the habitat, degree of habitat fragmentation and the proximity of large suitable protected areas. A large suitable protected area is one in which several pairs could nest. The average inter-nest distance on parts of Vancouver Island is about 9 km (McClaren 1998). At these inter-nest distances, a large, suitable protected area (for 4 pairs) would be approximately 26,000 ha or more of goshawk habitat. For example, Strathcona Park could be a core protected area for goshawks which may help support viable populations in central Vancouver Island. Therefore, to keep populations of goshawks throughout their range on Vancouver Island, WHAs might be located further north or south in parts of Vancouver Island where such a reserve does not exist.

5 RESEARCH PRIORITIES

The authors consider the following list of research activities to be necessary for the science-based management of Northern Goshawks and their habitat in British Columbia. Research will benefit from continuing regular communication between the researchers involved to a) share techniques; b) standardise methodologies; and c) refine conservation strategy details. Items 1–7 are considered high priorities.

1. Conduct a Conservation Assessment (CA) on the Northern Goshawk to determine if implementation of the Biodiversity Guidebook and Identified Wildlife Management Strategy is sufficient to conserve populations. If not, then consideration should be made to include Northern Goshawks in regional Higher Level Plans.

2. Monitor known nesting sites for use and productivity, with particular reference to the efficacy of the general wildlife measures. Assemble data on habitat attributes including proximity to industrial activity, second growth, and different forest types so that the degree of fragmentation that is tolerated by Northern Goshawks can be determined. This information can form the basis of subregional habitat suitability algorithms.

3. Conduct adaptive management within the framework of the IWMS. Within the constraints of the IWMS, some experimental WHAs can be set up and monitored to evaluate usefulness in proximity to clearcuts, second growth, agricultural areas and other edges, and size. Where variances allow, experimental harvesting practices related to opening sizes, stem density, understorey development, canopy closure, managing for old-growth structural characteristics, CWD and access can also be monitored [see discussion in Crocker-Bedford (1998)].

4. Determine if *A. g. laingi* is a subspecies with significant genetic differences from *A. g. atricapillus*. If there are significant genetic differences, then the argument for conservation urgency for *A. g. laingi* becomes greater; if not, then it becomes less. Two genetic studies failed to find such differences but samples from Vancouver Island and the Queen Charlotte Islands were not used (Gavin and May 1995). Morphological differences have been substantiated between island populations and those on the mainland (Whaley and White 1994; Flatten et al. 1998). Blood is currently being collected from all birds captured in BC; therefore, much of the needed material is on hand, with the exception of QCI. A sample of birds from QCI should be captured and blood collected; very small numbers of birds and limited opportunities to live-capture birds have precluded collection of blood.

   Caveat: It should be noted that failure to find a clear genetic difference between blood samples does not rule out the possibility that populations vary at the level of subspecies. In the absence of definitive blood analysis, several of the other factors that go into the determination of taxonomic status can be examined. The sub-species determination for *A. g. laingi* was made on the basis of colour and morphometrics. Standard measurements and comparison to Munsel colour charts should be made every time a bird is handled. The morphometrics that have already been collected should be examined to see if the subspecific distinction between insular and mainland populations continues to be supported. Behavioural differences can also be used.

5. Conduct nest surveys (including protected areas to assess their suitability as population sources) to build a stronger picture of the distribution, density, habitat use and preferences in British Columbia. More inventory effort should be undertaken on the

coast. Given the threatened status of *A. g. laingi* it is imperative to inventory protected areas; if habitat for significant numbers of breeding pairs are protected then less urgency can be applied to the conservation initiatives. Given limited resources and the high cost of finding nests, random sampling may not be the best use of resources. Stratifying areas to be surveyed, using current knowledge, then surveying those areas with the highest quality habitat that have the highest probability of containing nests may be the best approach.

6. Use radio telemetry selectively to determine home range sizes and the importance of different parts of an individual's home range. At present there are few data from British Columbia populations. It is necessary to have at least some idea if *laingi* home ranges on Vancouver Island and QCI are similar to those reported for southeast Alaska. Telemetry is also an effective tool for finding nests, testing nest fidelity and determining mortality factors (Iverson et al. 1996).

7. Obtain information regarding nesting densities and home range sizes in a variety of ecosystem types will lead to better population estimates. There is no provincial population size estimate for either subspecies, nor have population viability assessments been conducted. Information regarding nesting densities and home range sizes in a variety of ecosystem types will lead to better population estimates. The success of any population modelling will depend on incorporating factors associated with tolerance of habitat fragmentation (minimum critical areas), and minimum adequate prey base populations. Data describing population structure (sex and age ratios), breeding frequencies and reproductive life span, as well as accurate survival rate estimates over time, will be required before insight into population trends is achieved, but these data will be very expensive to obtain. At this point, the critical question of whether either subspecies' population is experiencing growth, decline or stability, can not be answered, as our current level of knowledge is inadequate to determine population trends. In order to address this, populations should be monitored on a watershed or population level to assess significant changes in density.

   Caveat: While we can use adaptive management, monitoring and research to find the lower levels of tolerance for habitat fragmentation and simplification, there is a biological risk to this approach. This low level of habitat maintenance may work during good prey and weather years, when we still have the legacy of large population of long-lived birds. Given adverse conditions in the future, however, the level of habitat maintenance may not prove to have been biologically viable.

8. Continue to monitor prey items used by goshawks by examining pellets and prey remains and by direct observation. This will enable us to detect differences in the importance of certain prey items between landscape types. Most research indicates that the prey base is fairly broad, particularly as the range of the species moves into lower latitudes.

9. Explore environmental factors that may affect goshawk productivity. For example, in Italy there is a strong negative correlation between rainfall during the nestling period and survival of the nestlings (Penteriani 1997). Current and future information on nest success can be examined in light of this possible link.

10. Determine where the birds are spending the winter and what the dynamics are of their prey base on their winter range. So far the research in BC has concentrated on breeding location and success. The winter ecology of goshawks has not been researched although winter survival may be the critical factor driving population levels. In Europe, winter food supply was found to be the key to breeding success (Widen 1987).

6 EVALUATION OF THE CONSERVATION INITIATIVE

An evaluation of the conservation initiative is required in order to assess the effectiveness of the initiative. However, because of the difficulty in acquiring data on nesting goshawks, evaluating the success of the initiative will be an arduous task. Resources will need to be shifted from the search for new nests to monitoring known nesting sites. Nevertheless, the following points should be considered.

1. Monitor as many known nest sites as possible, preferably all, for activity over the next five years. Province-wide, there is a considerable sample size of nests that could be used to assess effectiveness of any management techniques used.

2. Develop research hypotheses and methods to allow the evaluation of goshawk nest occupancy and breeding success relative to management techniques and degree of forest development; for example, compare activity and productivity between 1) those nests with WHAs and nests without WHAs; 2) nests with various intensities and proximity of industrial activity; 3) nests in habitat with various degrees of fragmentation or different silvicultural trials, and 4) nests close to source habitats compared to those isolated by fragmentation.

3. Create a provincial Northern Goshawk specialist position within the Wildlife, Habitat and Enforcement Branch of the Ministry of Environment, Lands and Parks. *A. g. laingi* is a subspecies at considerable risk and both *A. g. laingi* and *A. g. atricapillus* have considerable potential impact on forest management practices under the Forest Practices Code. Such a position would require an appropriate operating budget to coordinate the research, inventory, and evaluation needed to help conserve Northern Goshawks in British Columbia. The job is simply too time-consuming for provincial biologists with significant other responsibilities.

4. Conduct an annual comparative analysis of Northern Goshawk projects for nest site attributes and other significant features. This would identify similarities and differences between ecosystems and help with interpolation and models.

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Appendix 1. Step-down Management for Northern Goshawks in British Columbia.

Using the tools currently available in British Columbia, several steps can be taken towards management of Northern Goshawks. It remains to be seen whether or not these are adequate to maintain viable populations throughout their range.

1. Map known nest sites and known areas that have been removed from the timber harvesting land base at a subregional level.

2. Use landscape unit planning tools (old-growth management areas and wildlife tree patches) to protect known nest sites or areas of high probability of nesting or foraging activity.

3. Propose WHAs where they can be used to augment an old-growth management area or other constrained area in the case of *A. g. atricapillus*, or in the most undisturbed sites in the case of *A. g. laingi*.

4. Monitor goshawk activity near all known nest sites to build a database relating successful nesting attempts with habitat attributes and the timing and extent of disturbances.

5. Stratify areas at the Forest District level that have not been inventoried and identify areas with a high probability of goshawk occurrence and nesting.

6. Concentrate survey efforts on high quality habitat, then survey lower quality habitat.

7. Increase awareness of goshawks among those who work in the woods to assist in the location of nest sites.

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